Physical and Chemical Effects of Mountaintop Removal and Valley Fill Mining on Stream Biota

by J. Bruce Wallace, University of Georgia, Athens

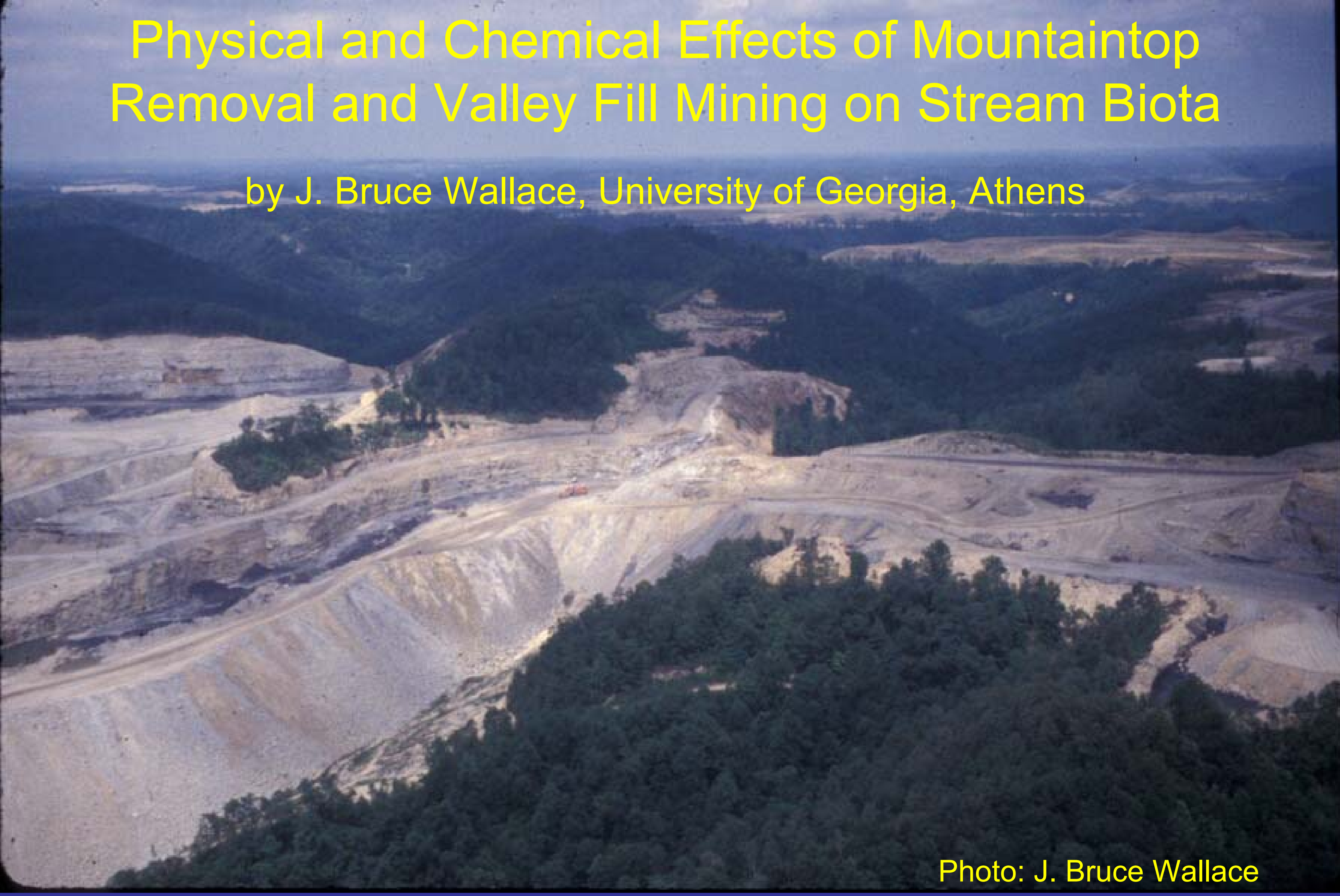
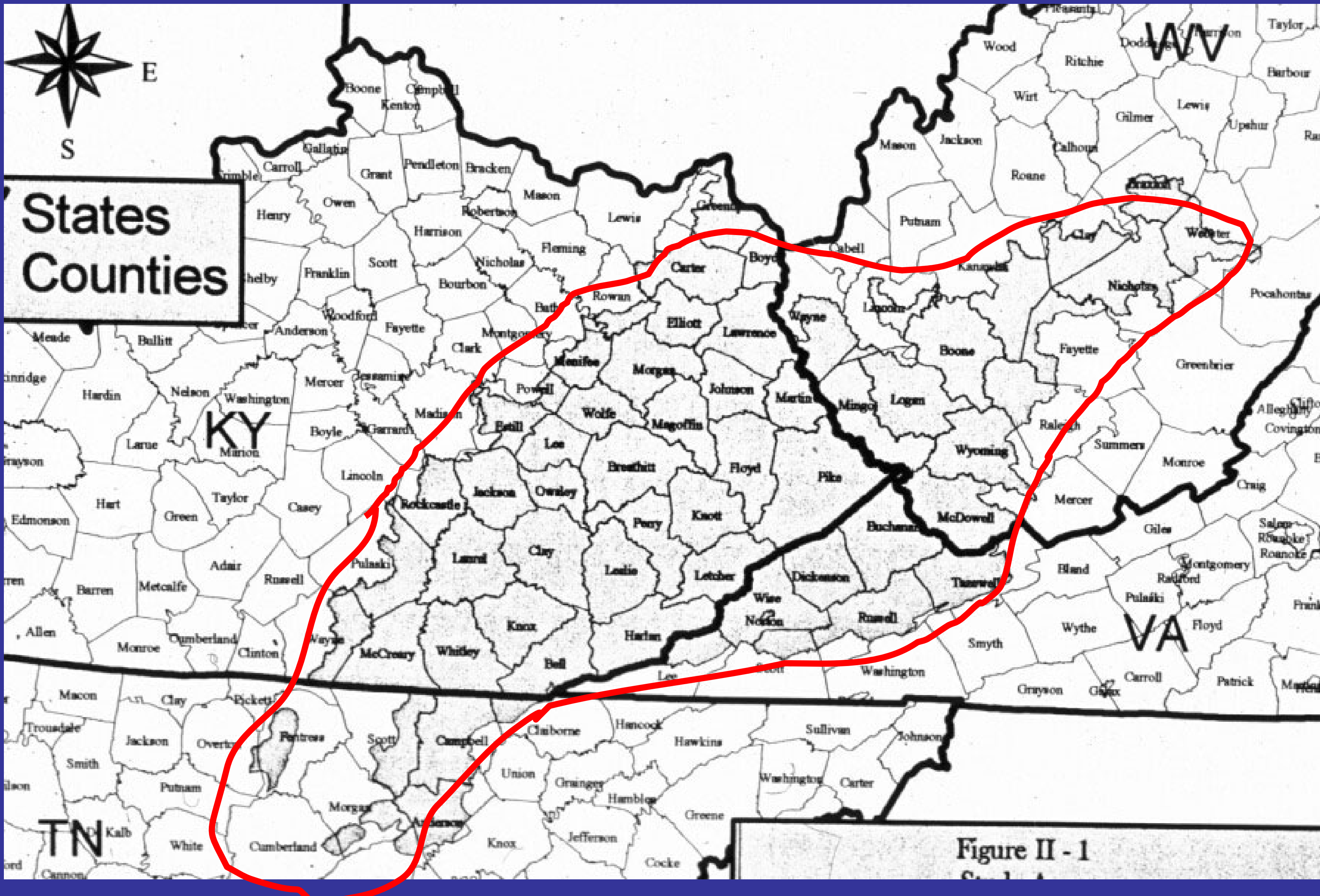


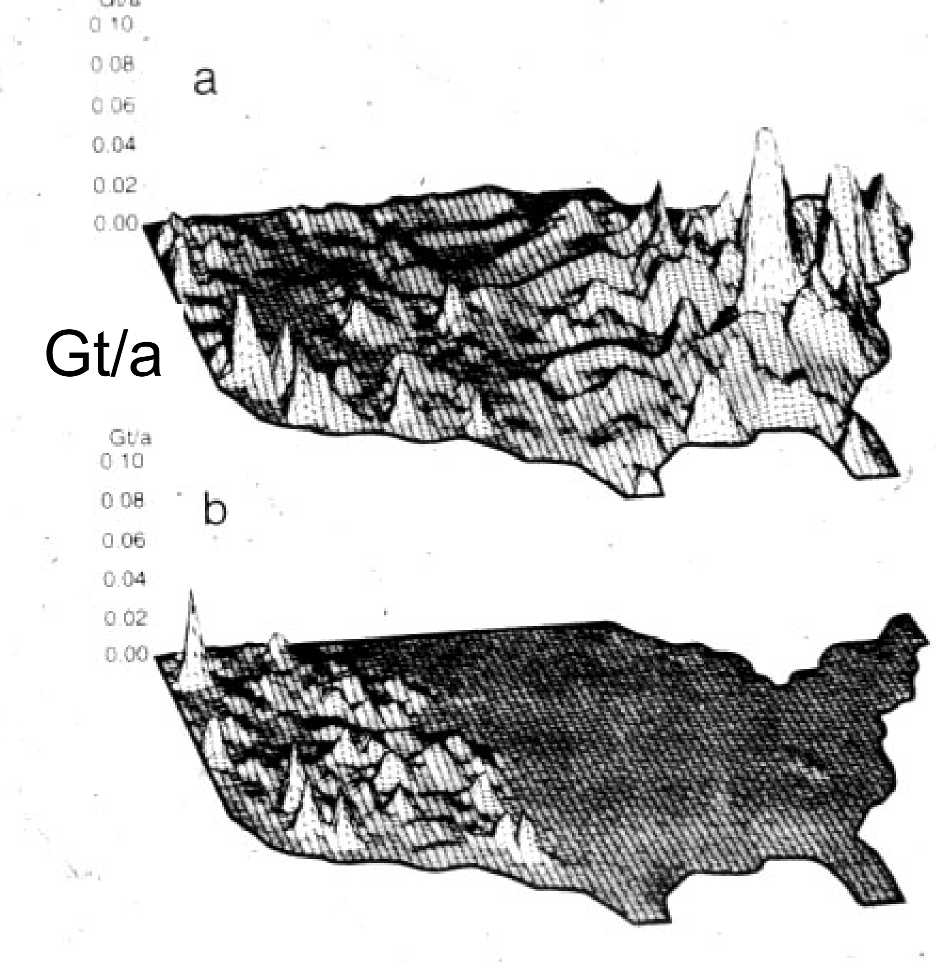
Photo: J. Bruce Wallace

1985-2001, some 500,000 acres of diverse Appalachian hardwood forest had been destroyed, by the end of the next decade 1.4 million acres destroyed (an area about the size of Delaware).

Photo courtesy of Vivian Stockman OHVEC



E
S
States
Counties
KY
WV
VA
TN
Figure II - 1



Map of the United States showing, by variations in peak height, the rates at which earth is moved in gigatonnes per annum in a grid cell measuring 1° (latitude and longitude) on a side, by (a) humans (top) and (b) rivers (bottom)

From R. L. Hooke.1999. Spatial distribution of human geomorphic activity in the United States: comparison with rivers. Earth Surface Processes and Landforms 24:687-692


Mountaintop removal/valley fill (MTR/VF) mining gets it’s name from exactly what it is – removal of mountaintops and filling of valleys with overburden from mining activities (mining companies lexicon = steep slope mining)
Photo: J. Bruce Wallace

~ 1200 miles of Appalachian streams have been filled, buried up to 450 feet with overburden from mining activities

Photo: J. Bruce Wallace

The projection of stream miles lost are undoubtedly conservative:

1. USGS 1:24,000 scale
2. Blue lines do not agree with field conditions
3. Leopold 1994 “A View of the River”


Photo: J. Bruce Wallace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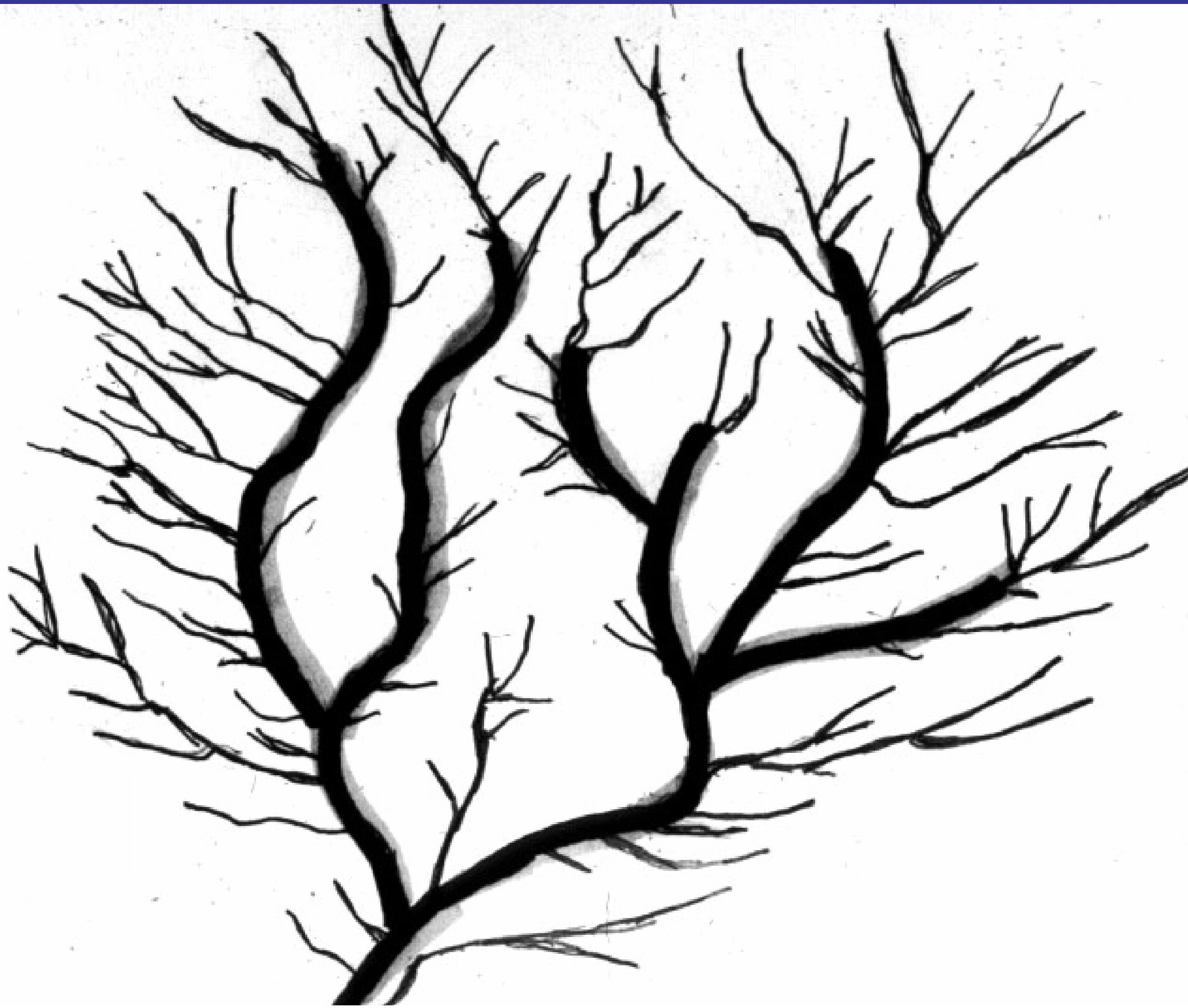
Coweeta Hydrologic Laboratory USFS



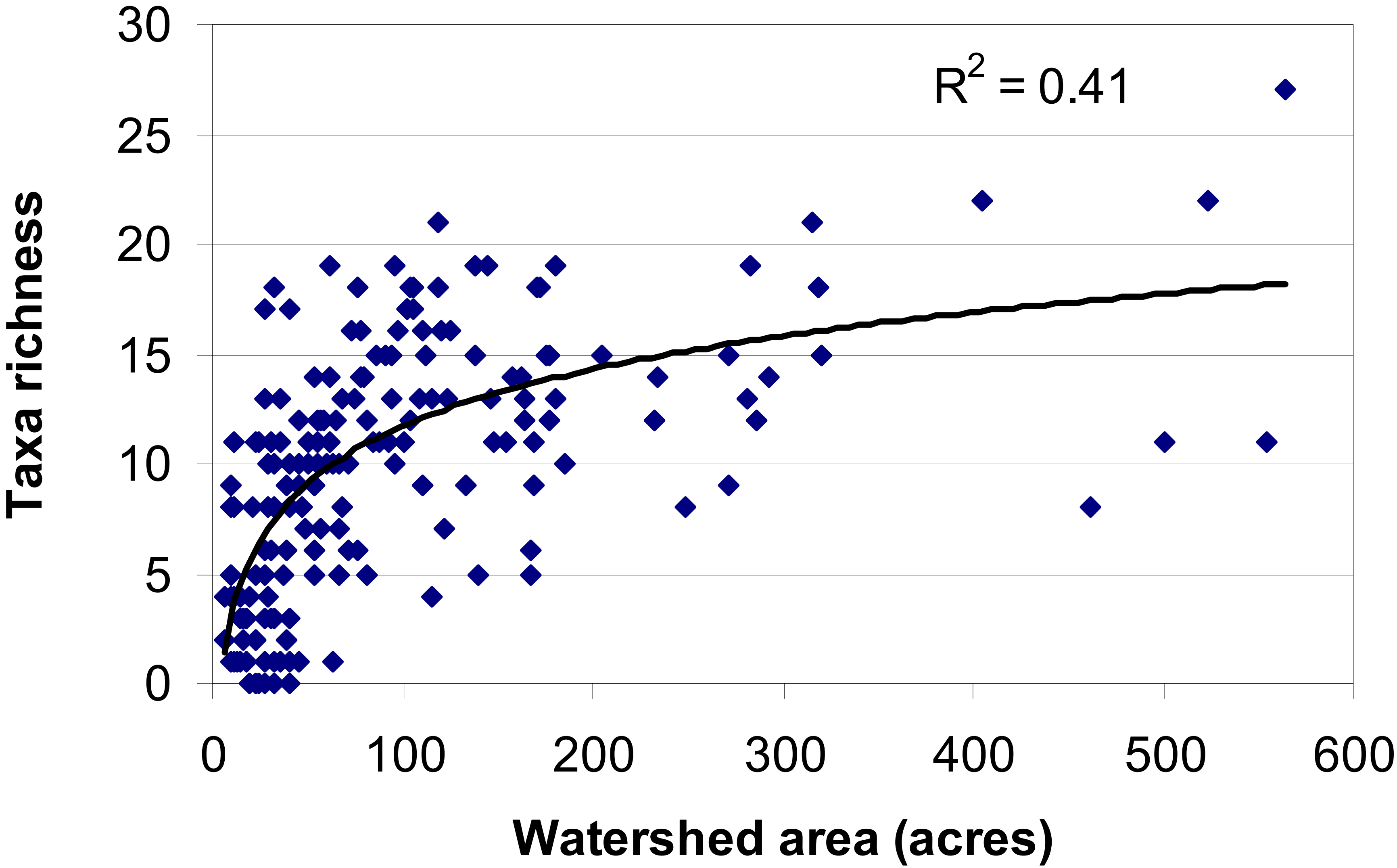
Coweeta Hydrologic Laboratory, number of perennial streams on a 1:7200 scale map are over 2 X that found on a 1:24000 scale map. Yet, there are numerous perennial seeps and small spring runs that do not appear on the 1:7200 scale maps.

Perennial stream – flows continuously and has flow from both groundwater discharge and surface runoff

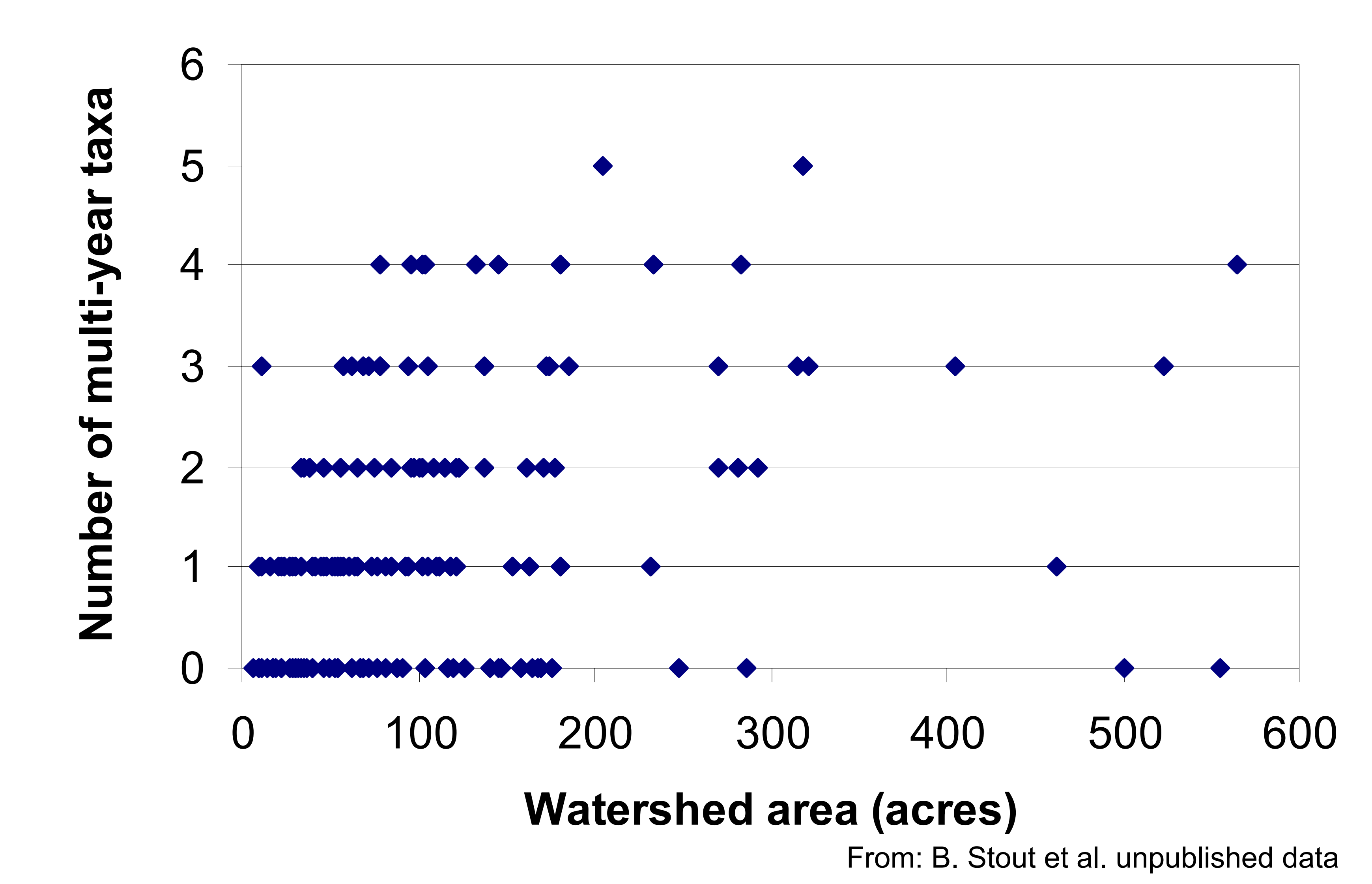
Intermittent stream – flows only during a portion of the year from both groundwater and surface runoff

Ephemeral stream – flows in response to surface runoff from precipitation or melting snow

The State of West Virginia – also has a biological definition of an intermittent stream – "Streams which have no flow during sustained periods of no precipitation and do not support aquatic life whose life history requires a residence in flowing water for at least 6 months."

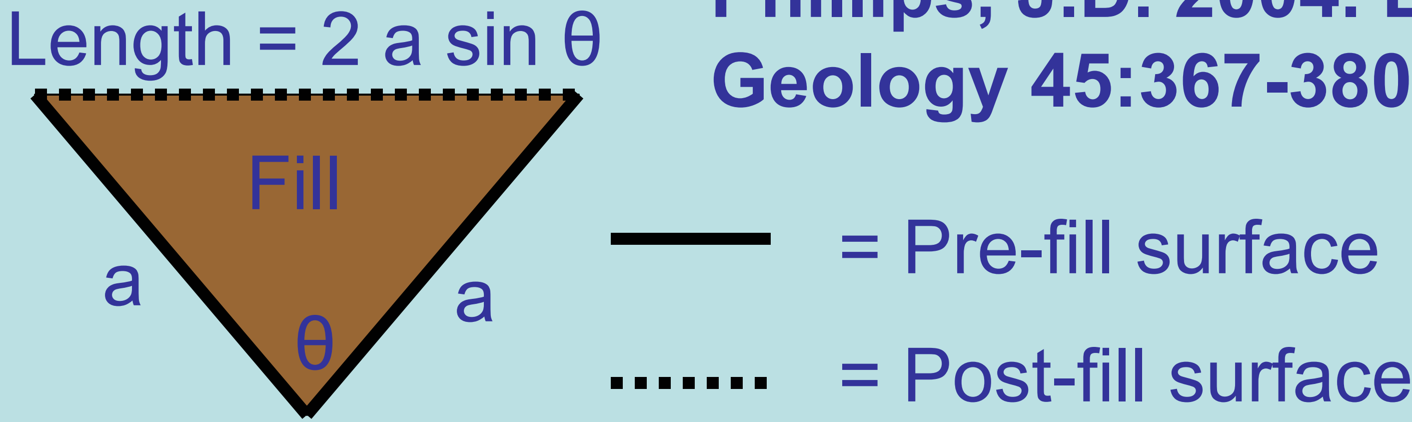


From: B. Stout et al. unpublished data



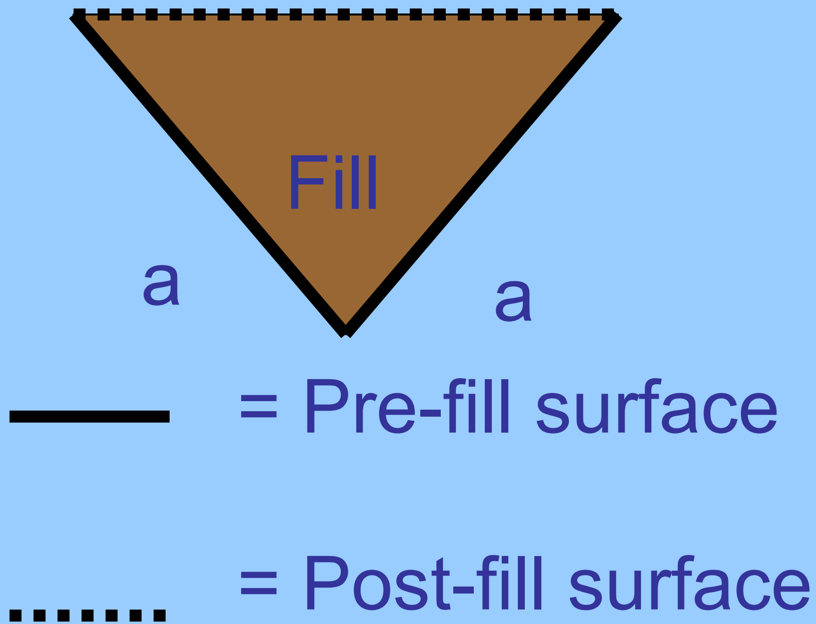
Number of multi-year taxa
6
5
4
3
2
1
0
0
100
200
300
400
500
600
Watershed area (acres)
From: B. Stout et al. unpublished data

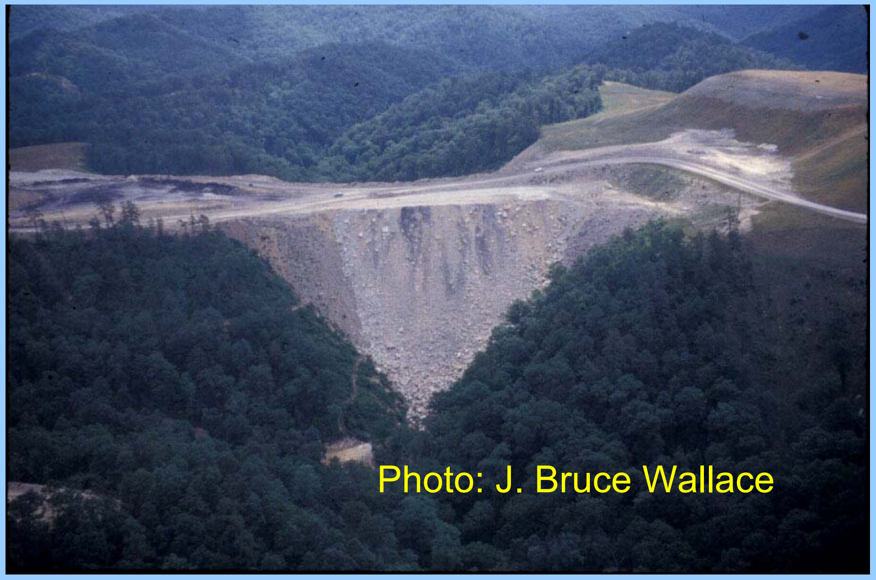
Phillips, J.D. 2004. Environ. Geology 45:367-380.



Used a variety of indices to model relative flow detention times: i.e., average flow lengths, infiltration based on soil types, soil moisture storage capacity, slope gradients, surface roughness, hydraulic conductivity, and radar analyses of precipitation images, surface versus subsurface flow, etc. to estimate impact of fills on headwater flooding in eastern Kentucky.


From NOAA





Subsurface flow detention time increases with valley fills – fairly thin pre-mining slopes – replaced with fill

Most valley fills have greater minimum flows than un-mined basins because of groundwater storage > released during dry periods > this has some important implications for downstream biota and ecosystems.

After Phillips 2004

Phillips (2004) –

- there is a risk of increased flooding (greater runoff production and less surface flow detention); however, there was a wide range of outcomes.
- effects of MTR/VF on flash floods are highly contingent on pre- versus post-mining conditions.
- prior attributions to differences in mined and un-mined catchments are unlikely to be due to localized variation in rainfall among nearby basins.
- between site differences are important and a great deal of variation occurs among sites as some sites show no tendency toward increase flooding.

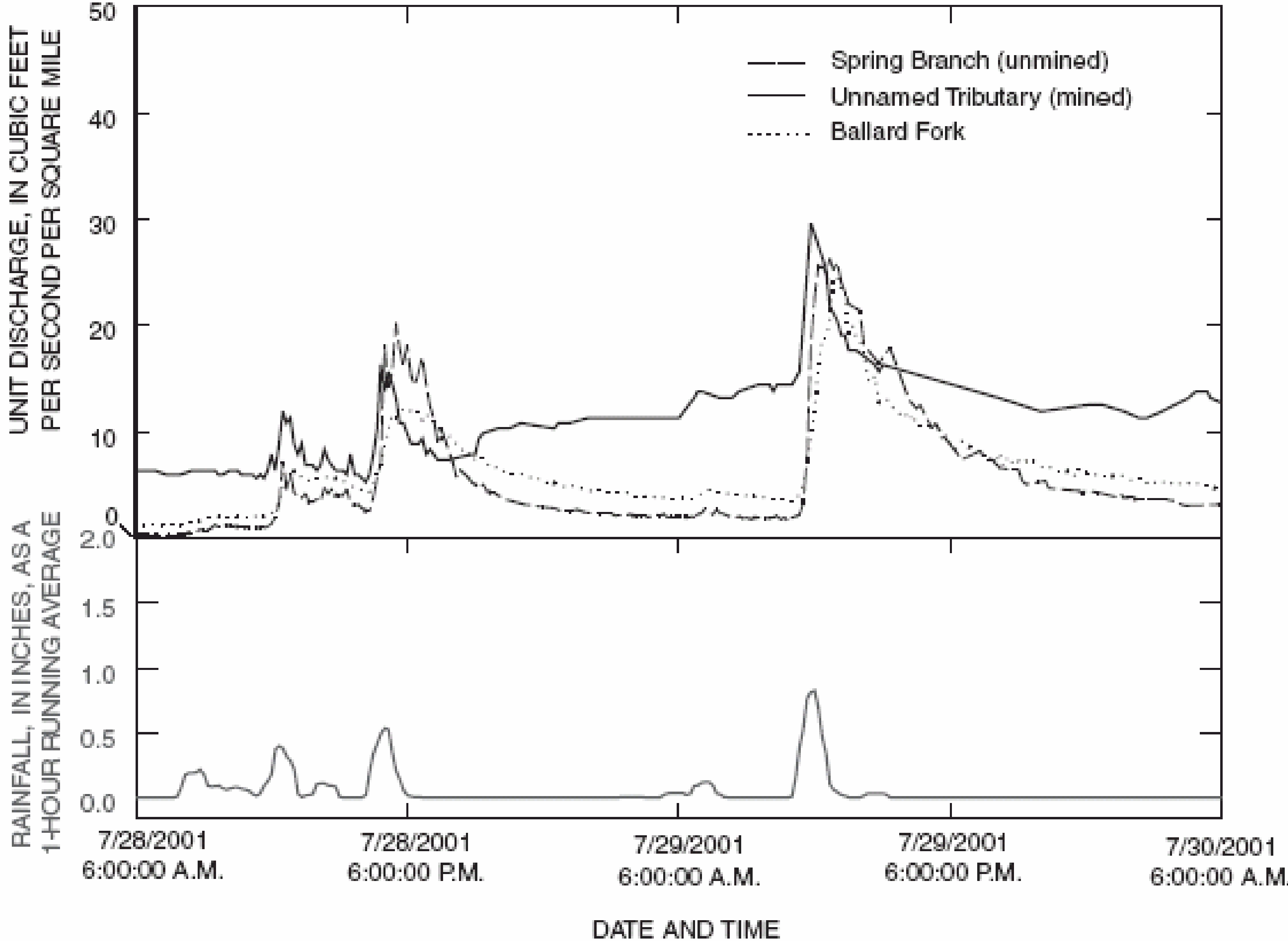


Figure 6. Storm hydrograph for July 28–30, 2001, for three stream-gaging stations, and rainfall as a 1-hour running average for four rain gages in the Ballard Fork Watershed, West Virginia.

From: T. Messinger.2003. WRI Report # 02-4303

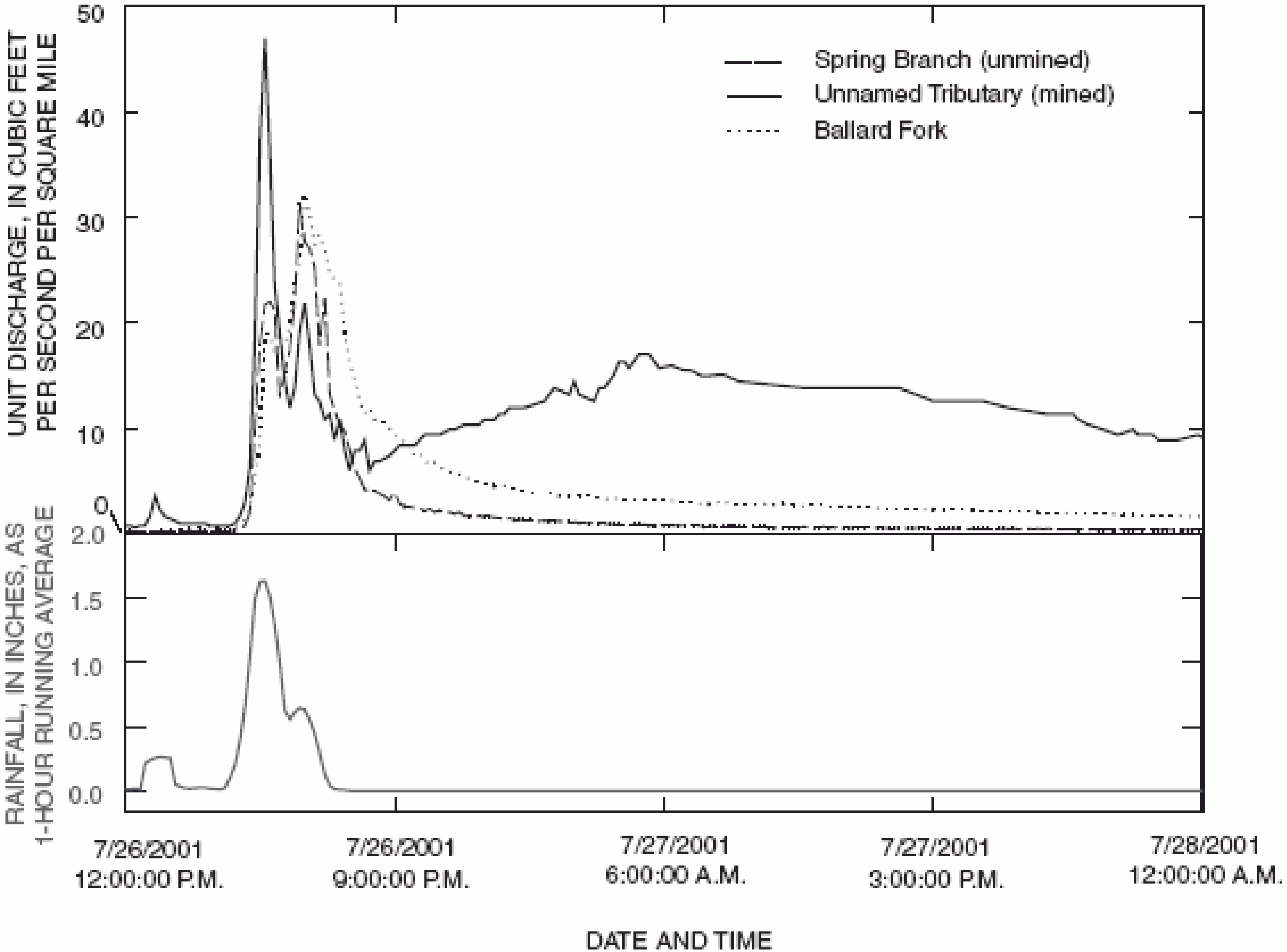


Figure 5. Storm hydrograph for July 26–28, 2001, for three stream-gaging stations, and rainfall as a 1-hour running average for four rain gages in the Ballard Fork Watershed, West Virginia.

From: T. Messinger.2003. WRI Report # 02-4303

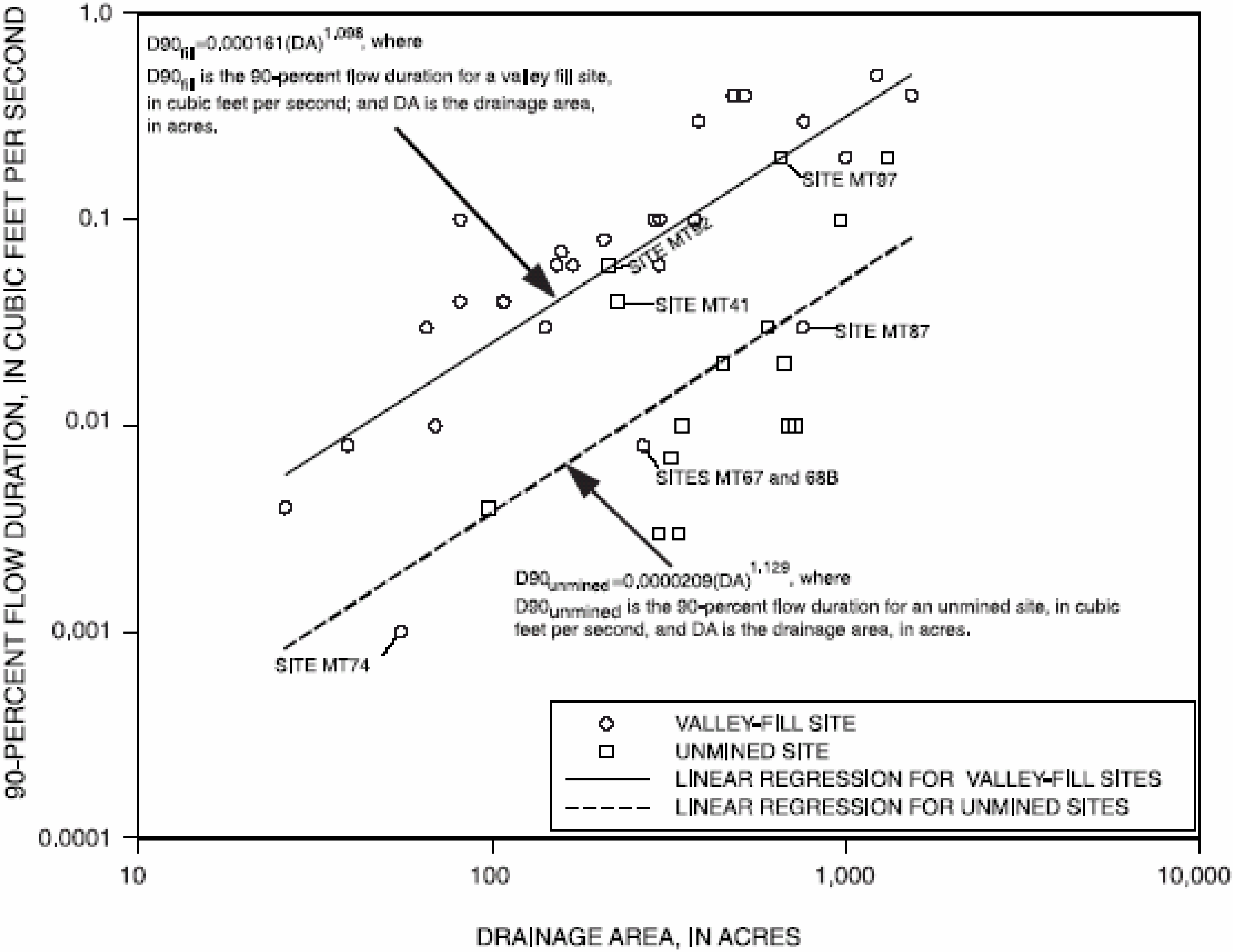


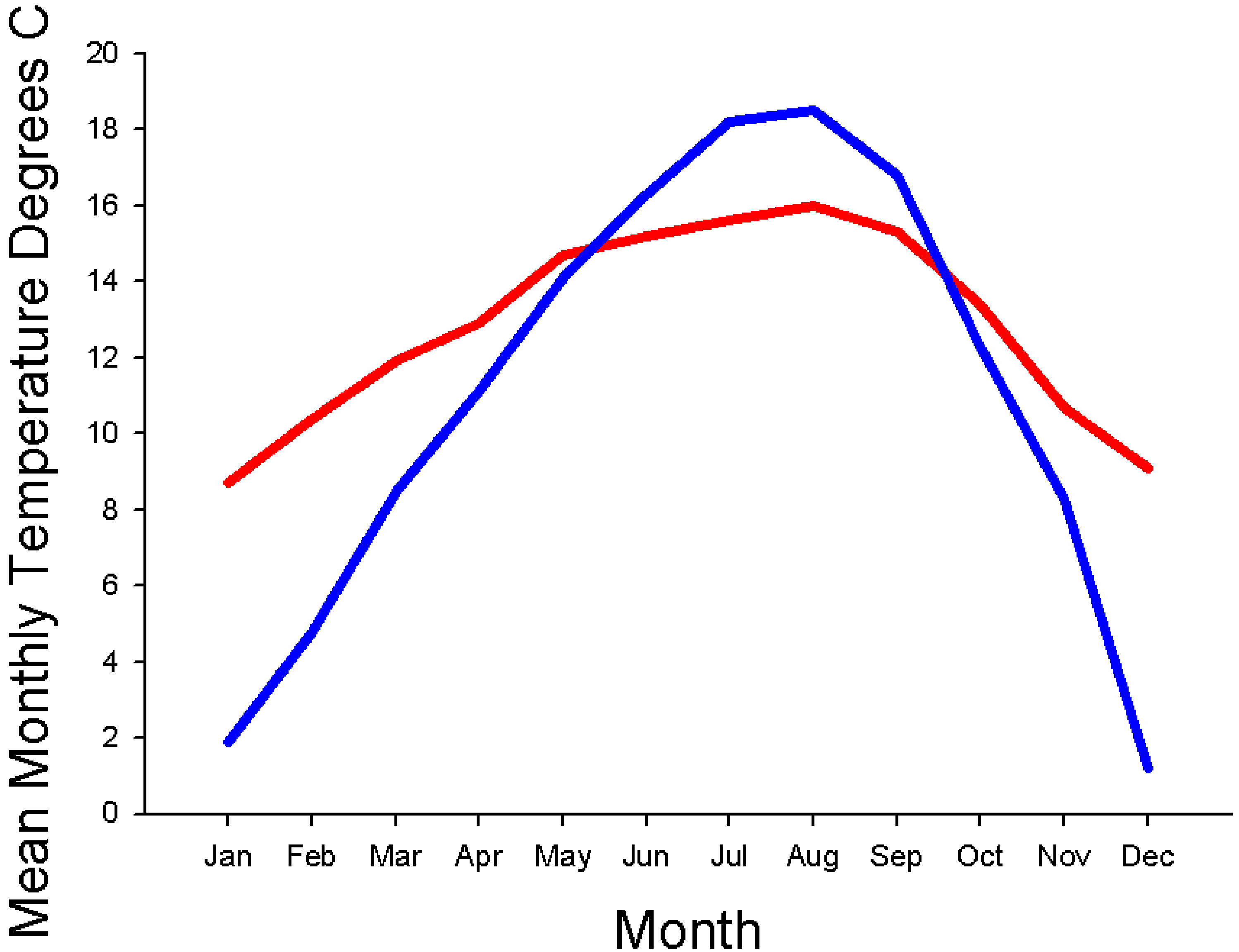
Figure 5. Comparisons among the 90-percent flow durations and drainage areas for valley-fill and unmined sites in the coal-mining region of southern West Virginia.

From: Wiley et al. 2001, WRI Report 01-4092

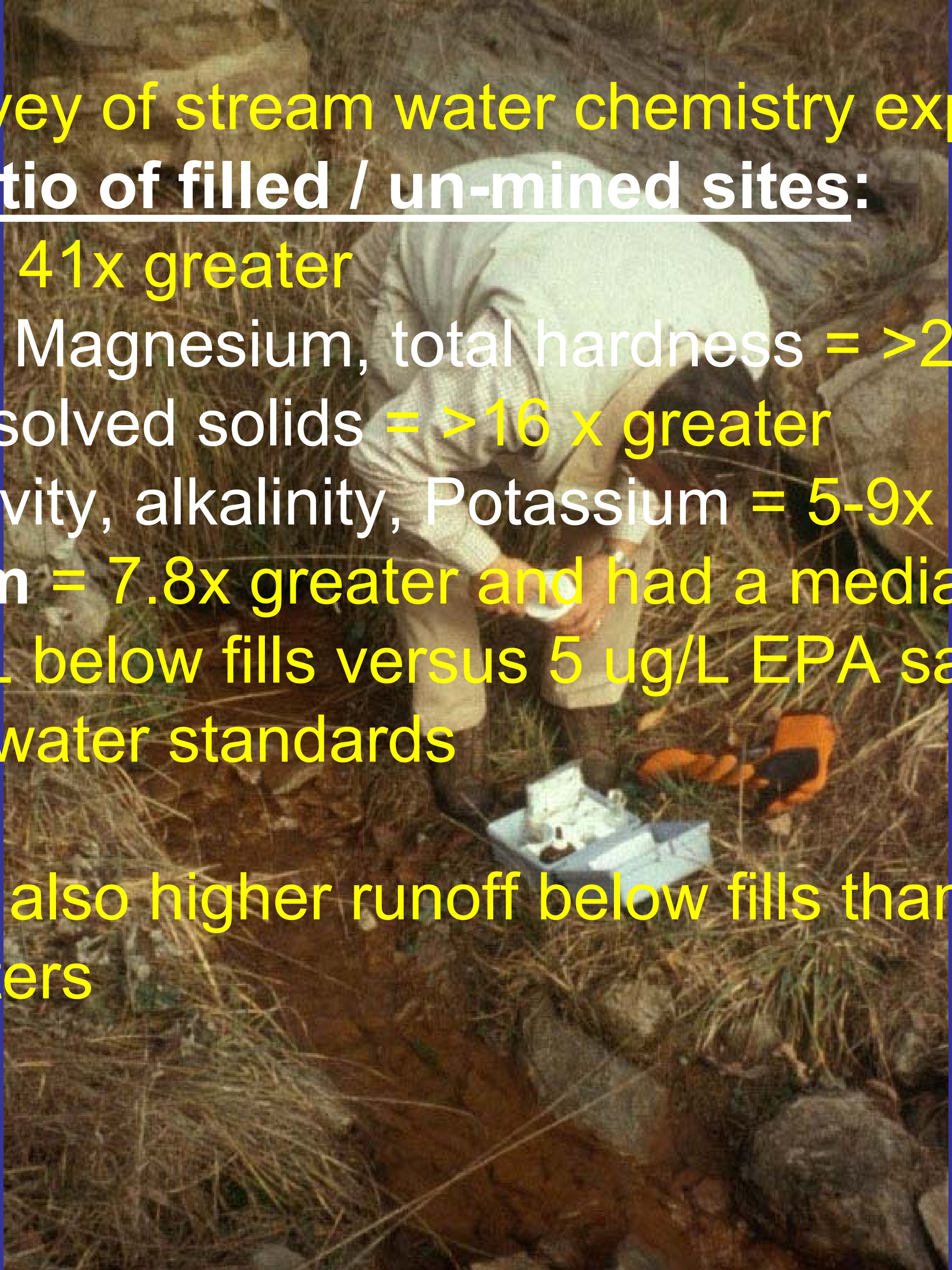
According to Phillips 2004:

Need more before mining - versus after mining long-term studies addressing impacts of specific events at specific sites on stream flooding

“the idiosyncratic nature of hydrologic response makes extrapolation of results problematic”



Calculated from data in table format in Wiley et al. 2001, WRI Report 01-4092



EPA survey of stream water chemistry expressed as the **ratio of filled / un-mined sites**:

Sulfate = 41x greater

Calcium, Magnesium, total hardness = >21x greater

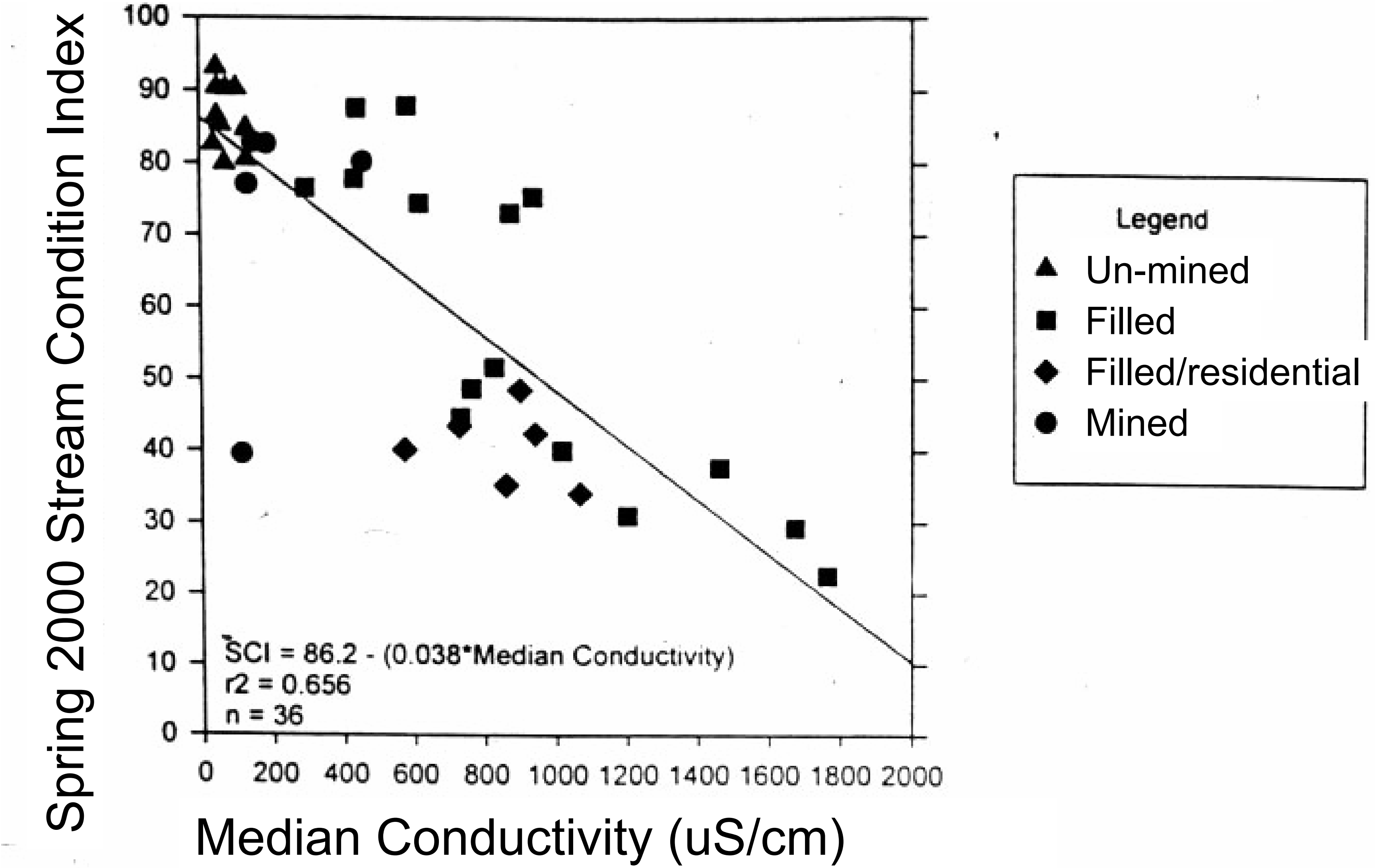
Total dissolved solids = >16 x greater

Conductivity, alkalinity, Potassium = 5-9x greater

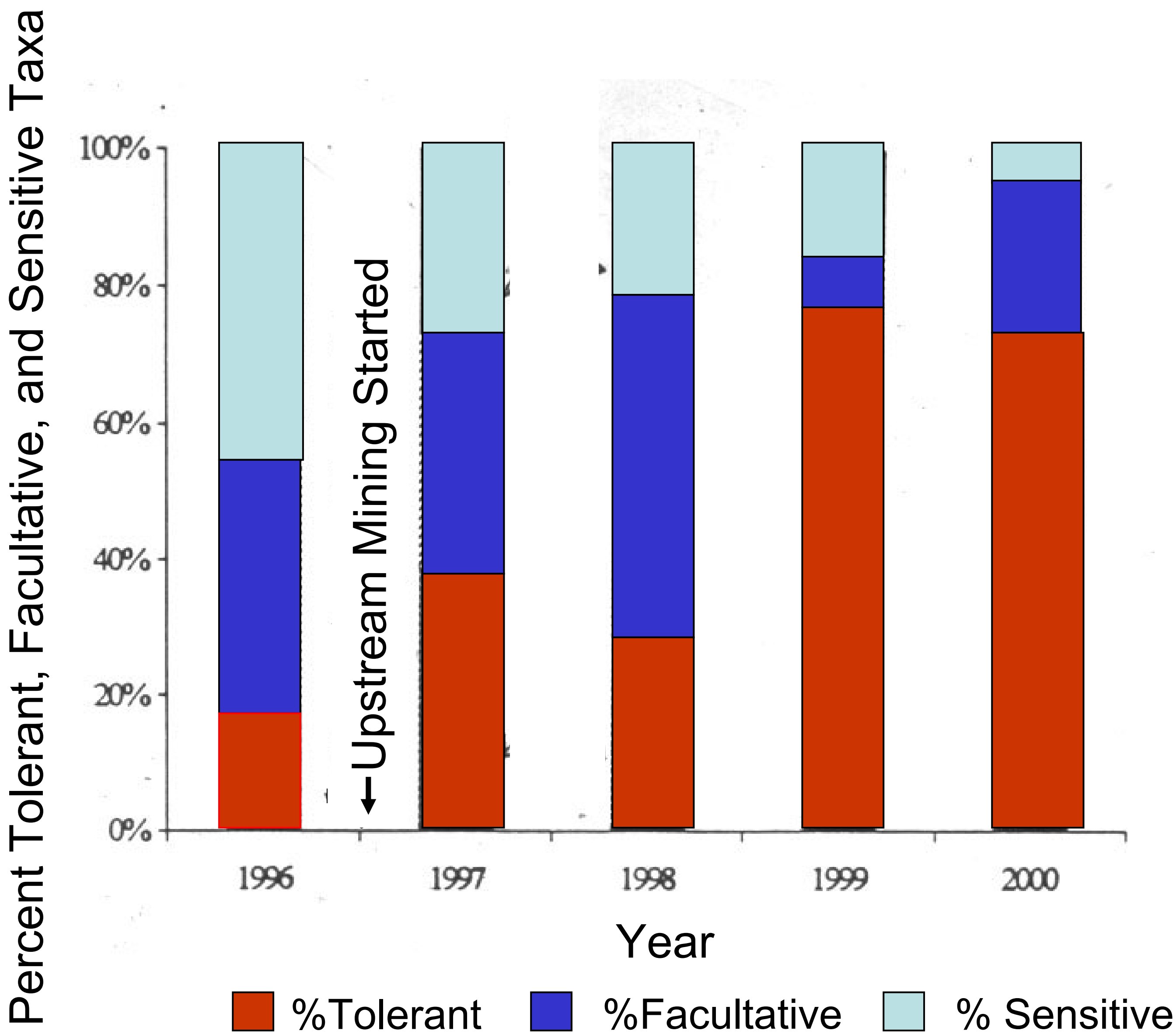
Selenium = 7.8x greater and had a median value of 11.5 ug/L below fills versus 5 ug/L EPA safe drinking water standards

There is also higher runoff below fills than forested headwaters

Relationship between Stream Condition Index and median conductivity.



From: J. Green, M. Passmore, and H. Childers. 2000. U.S. E.P.A., Report from Region 3, Wheeling WV.



Source: REI Consultants, Inc. and Penn Coal Company

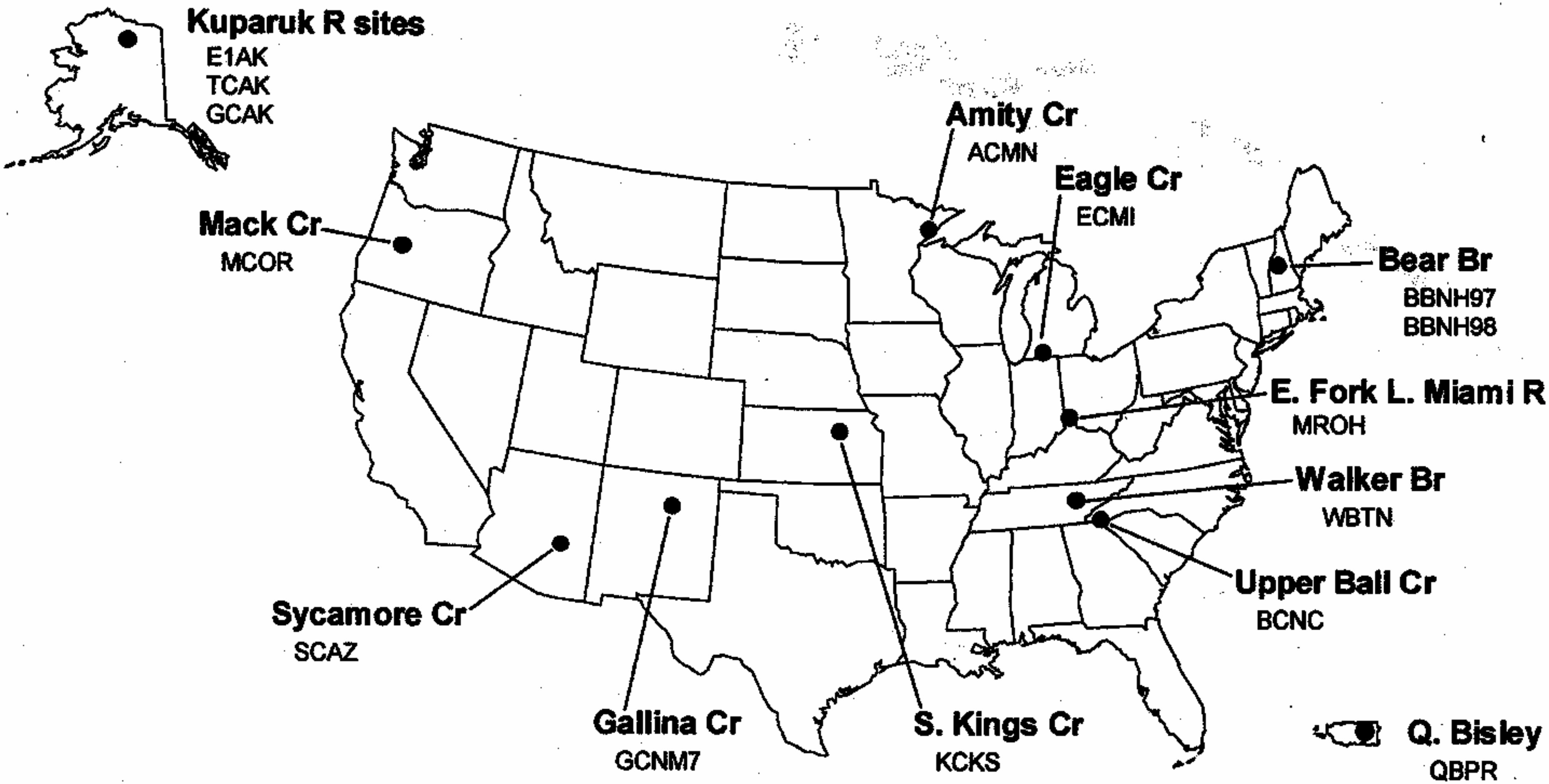
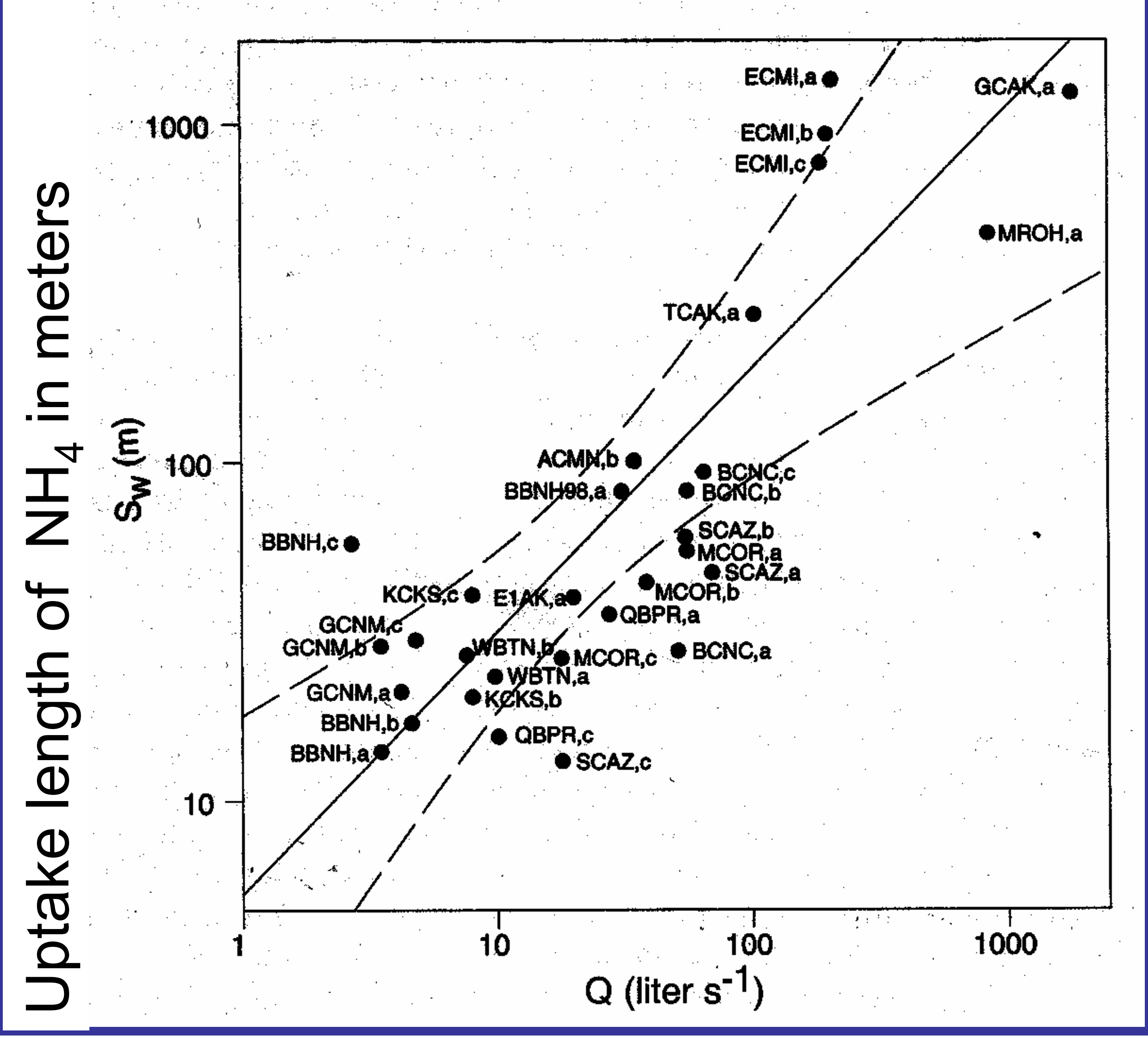


Fig. 1. Location of the LINX study streams. Letters below stream names indicate codes for streams and locations (e.g., BBNH = Bear Brook, New Hampshire). See Web table 1 (*15*).

Source: Peterson et al. 2001, Science 292: 86-90



Source: Peterson et al. 2001, Science 292: 86-90

Summary:

1) Hydrology very variable below fills – few detailed long-term flow studies…

2) Increased hydrologic detention and flow duration…

3) Various chemical and physical problems that impact downstream biota …

4) Increased concentrations of chemicals combined with increased water yield = increased loading …

5) Long-term effects of valley fills on downstream areas…..

6) Consequences of the loss of detrital inputs to headwater streams to downstream reaches…..